M.E. 227.3 Thermodynamics I
Department of Mechanical Engineering
Final Examination
2:00pm December 19, 2000

Time: 3 hours
Calculators Allowed
Formula Sheet Supplied

Total Marks: 100
Closed Book
This exam has SIX questions

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(10) 1. Briefly define the following terms:

   (a) Reversible process.
   (b) Critical point.
   (c) Quality.
   (d) Adiabatic.
   (e) Polytropic process.

(10) 2. Describe the conditions under which the assumption of constant specific heats for an ideal gas is valid. Why?

(20) 3. A piston–cylinder device contains 1 kg of air which undergoes a cycle consisting of the following three reversible processes from an initial state of $P_1 = 100\,kPa$ and $T_1 = 200^oC$.

   (a) adiabatic expansion
   (b) constant volume process
   (c) constant temperature process

The net work for the cycle is $-6.3\,kJ$. Sketch the cycle on $P - v$ and $P - h$ coordinates. Find the heat transfer for each of the three processes. Assume that air behaves as an ideal gas ($R = 287\,J/kg/K$) with constant $c_v = 720\,J/kg/K$. (0, 61.5 kJ, −67.8 kJ)

(20) 4. A perfectly–insulated, $0.5\,m^3$, rigid vessel is initially empty but develops a small leak and eventually fills with air from the surroundings which are at $100\,kPa$ and $300\,K$. What is the mass of air in the vessel when flow eventually stops? Assume that air behaves as an ideal gas. (0.415 kg)

(20) 5. A vapour compression refrigeration system uses R134a as its working fluid. The evaporator and condenser pressures are 2 bar and 7 bar respectively. The temperature at the inlet to the compressor is 0^oC and the isentropic efficiency of the compressor is 85%. The refrigeration effect is 8 kW and the coefficient of performance is 5.2. What is the flowrate of the refrigerant and what input power is required? What is the quality at the inlet to the evaporator?
0.0481 kg/s, −1.54 kW, 23%

(20) 6. An ideal Rankine cycle with reheat operates with steam generator outlet conditions of 8 MPa and 531.4^oC. The condenser pressure is $20\,kPa$. Assume that the exit of the condenser is a saturated liquid. If all liquid is to be eliminated from the turbines, calculate the minimum pressure at which a reheater can be installed and the minimum amount of reheat which must be added (in kJ/kg). What is the thermal efficiency of the cycle under these conditions?
500 kPa, 602.7 kJ/kg, 38.2%

M.E. 227.3 Thermodynamics I
Department of Mechanical Engineering
Final Examination
9:00am December 10, 2001

Time: 3 hours
Calculators Allowed
Formula Sheet Supplied

Total Marks: 100
Closed Book
This exam has SIX questions

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(10) 1. Briefly define the following terms:

(a) Thermal equilibrium.
(b) Extensive properties.
(c) Reheater.
(d) Clausius Inequality.
(e) Ideal gas.

(10) 2. Briefly explain why the sudden expansion of a gas is an irreversible process.

(20) 3. A piston–cylinder device contains 2.5 kg of air which undergoes a power cycle consisting of the following three reversible processes from an initial state of 100 kPa and 200°C.

(a) constant volume process to 400°C
(b) adiabatic expansion
(c) constant temperature process

(16.7%)

Find the thermal efficiency of this cycle. Assume that air behaves as an ideal gas ($R = 0.287\,\mathrm{kJ/(kg\cdot K)}$) with constant $c_v = 0.720\,\mathrm{kJ/(kg\cdot K)}$.

(20) 4. A turbine receives superheated steam at 10 MPa and 520°C. The expansion through the turbine follows $Pv^{1.3}$ =constant. The turbine exit is at 1 bar. Determine the amount of heat transfer between the turbine and the surroundings. (− 482.4 kJ/kg)

(20) 5. A vapour compression refrigeration system uses R134a as its working fluid. The condenser pressure is 7 bar and the evaporator pressure is 1 bar. The cycle rejects heat at a rate of 8.42 kW. The outlet of the condenser is subcooled by 4°C. The isentropic efficiency of the compressor is 85% and it performs 50.97 kJ/kg of work on the refrigerant. What is the refrigeration effect? What is the coefficient of performance? (6.41 kW, 3.21)

(20) 6. An ideal Rankine cycle has an open feedwater heater operating at 1 MPa. The steam generator outlet conditions are 8 MPa and 520°C. The condenser pressure is 30 kPa. Assume that the exit of the condenser is a saturated liquid. The temperature at the exit of the feedwater heater is 180°C. Clearly sketch the cycle on a $T-s$ diagram. What is the thermal efficiency of the cycle? (51.3%)

M.E. 227.3 Thermodynamics I
Department of Mechanical Engineering
Final Examination
9:00am December 10, 2002

Time: 3 hours	Total Marks: 100
Calculators Allowed	Closed Book
Formula Sheet Supplied	This exam has FIVE questions

(20) 1. A heat engine draws 10 kW of heat from a reservoir at 800 K. The work it produces drives a refrigerator which produces a refrigeration effect of 10 kW. Both devices reject heat to a reservoir at 300 K. What is the lowest possible temperature of the space cooled by the refrigerator? (184.6 K)

(20) 2. Air undergoes a Carnot power cycle in a closed system. The high and low temperature extremes are 700 K and 300 K. The high and low pressure extremes are 30 bar and 1 bar. Determine the net work (in kJ/kg) for this cycle. Assume that air behaves as an ideal gas ($R = 0.287\,\mathrm{kJ/(kg \cdot K)}$) with constant $c_v = 0.720\,\mathrm{kJ/(kg \cdot K)}$. (50 kJ/kg)

(20) 3. A proposed heat engine produces work at a rate of 6.5 MW while operating at steady state. Air enters the engine at 10 bar and 600 K and leaves at 1 bar and 500 K. The mass flow rate of the air is 1.2 kg/s. The engine also receives superheated steam at 20 bar and 500°C which leaves the engine as a saturated vapour at 1 bar. The engine is well insulated from its surroundings and kinetic and potential energy may be neglected. Assume that air behaves as an ideal gas with $R = 0.287\,\mathrm{kJ/(kg \cdot K)}$. Is the power output claimed possible? (Not Possible)

(20) 4. A vapour compression refrigeration system uses R134a as its working fluid. The entrance to the compressor is a saturated vapour and the exit of the condenser is a saturated liquid. The evaporator pressure is 1 bar and the isentropic efficiency of the compressor is 90%. If the refrigeration effect is 20 kW and the mass flow rate of refrigerant is 0.1383 kg/s, what is the coefficient of performance? What is the maximum possible coefficient of performance for any refrigerator operating between the same temperature limits? (3.24 , 3.71)

(20) 5. A Rankine cycle has an open feedwater heater operating at 1 MPa. The steam generator outlet conditions are 8 MPa and 520°C. The condenser pressure is 30 kPa. The pumps are isentropic but the turbines have efficiencies of 80%. The entrance to both pumps is a saturated liquid. What is the thermal efficiency of the cycle? (32.2 %)